IRRIGATION DEVELOPMENT AND FOOD SAFETY IN CHINA

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I. IRRIGATION PLAYS AN IMPORTANT ROLE IN CHINA'S AGRICUL-TURAL DEVELOPMENT

1. Specific climatic and geographic conditions define China's agriculture as irrigated agriculture

Half of China's territory is arid and semi-arid. In the north-western part of China, the annual rainfall is less than 250 mm and without irrigation there would be no agriculture. In the north-eastern and northern parts of China the annual rainfall is 400 - 600 mm, which substantially falls in summer and there is a spring drought almost every year. Irrigation is necessary condition for agricultural development. To the south of the Yangtze River, the annual rainfall is some 1000 mm. Despite the rich rainfall, its distribution is uneven and droughts occur very often both in summer and in autumn. In order to obtain high-level agricultural production, supplementary irrigation has to be carried out. Drought and water shortage have become major constraining factors for the development of agriculture in China. China's agriculture is to a large extent dependant on irrigation.

2. China has a long history of irrigation

Two thousand years ago, our forefathers had already built the world-famous Dujiangyan irrigation district in Sichuan Province. After several rehabilitation and modification many times, it is still being used. With an irrigation area of 10 million mu, it has become an economically developed region of the highest food production in Sichuan Province.

3. China's irrigation development in the last half-century

In 1949, the irrigated area of the whole country was 240 million mu accounting for only 16% of the country's farmland, and the per-capita food 209 kg. By the end of 1998, irrigated area had attained 800 million mu, accounting for 40% of the farmland, and the per-capita food was 400 kg.

In 1949, the water use for irrigation was approximately 100 billion m^3.

With the increase of irrigation area, the water use for irrigation gradually rose and reached 358 billion m^3 in 1980. After that, irrigation water use has been stabilized. On the other hand, industrial and municipal water uses have increased rapidly, thus leading to the dropping of the proportion of irrigation use in the whole water use of the country: 1949 - 92%, 1980 -80%, 1997 - only 65% (see Table 1)

Table 1 Population, farmland, irrigation water use and food production of the country for several years

Year	Irrigation use (10^9 m^3)	Proportion of irrigation use in total use (%)	Farmland area (10^9mu)	Irrigat. area (10^9 mu)	Food pro-duction of country (10^9 kg)	Popu-lation (10^9)
1949	95.6	92	1.468	0.24	113.2	0.54
1965	235	85	1.554	0.481	194.5	0.725
1980	358	80.5	1.490	0.733	320.6	0.987
1993	344	66.5	1.426	0.746	456.5	1.185
1997	359.8	65	1.420	0.784	494.2	1.236

Note: 1 mu = 1/15 ha.

Over the past several decades, especially since 1980, the efficiency of irrigation water use and the production efficiency have progressively risen. According to the actually irrigated land, the average water use for agricultural irrigation across the country in 1980 was 583 m^3/mu but it decreased to 520 m^3/mu in 1997 whereas the average specific food yield during the same period increased from 0.6 kg/m^3 to 1 kg/m^3.

4. Role of irrigation in the food production augmentation and national economic and social development

The development of irrigation has strengthened the agriculture's drought-resistant capacity, significantly improved the conditions of agricultural production, provided support to the extension of quality seeds, chemical fertilizer and other advanced agricultural techniques to greatly increase the yield of crops. Generally, the specific yield of irrigated farmland is 1 - 3 times that of arid farmland. Many counties each with farmland of several hundreds of thousand mu have attained an average food production level of 1000 kg/mu. Three fourths of food, cotton, oil, vegetable and etc. come from irrigated farmland in the country. The construction of irrigation works in poor areas may help the peasants be lifted out of poverty and backwardness.

The augmentation of irrigation area and food production has created conditions for the regulation of agricultural structure, as well as raised the proportion of livestock farming, fishery and economic crop output value in gross value of agricultural output. The development of irrigation has become one of the major causes for augmenting peasants' income. For example, over the last 20 years since 1978, the per-capita income of peasants has increased seven times.

The great successes in the development of irrigation and food production have allowed to support China's population equivalent to 22% of the world population with farmland less than 10% of the world farmland so that China can maintain social stabilization and the rapid growth of national economu.

II. ANALYSIS OF CHINA'S IRRIGATION DEVELOPMENT AND FOOD AUGMENTATION POTENTIALS FOR THE 21-ST CENTURY

1. Food demand

China has a very large population. At present, China's population is 1.248 billion and the peak of it is expected to be 1.6 billion in 2030. China's territory is large but farmland resources are few. The recent survey has shown an existing farmland of 1.95 billion mu and a per-capita farmland of 1.6 mu, accounting for 40% of the world average. The reserve farmland resources which may be further exploited are not many. Based on an estimated per-capita food of 400 kg, China's food demand in 2030 is expected to be some 640 billion kg. Beside that, the proportion of economic crops has also to be increased propoerly to increase the peasant's income and raise the living standard of the people. Under China's conditions, the key to the resolution of the imbalance between large population and inadequate farmland as well as that between large population and inadequate water is to develop irrigation, improve the conditions of agricultural production, make the most of agricultural techniques as well as increase specific yields and efficiency.

2. Development of irrigation and potentials to increase production

(1) Construct new facilities of irrigation and extend irrigation area. In the north-eastern and south-western parts of China, the proportion of irrigated farmland in the whole farmland is low, only 15-30%, which is lower than the country's average 40% and much lower than the 60-80% in south-central and eastern parts of China. These parts have relatively

better water resource conditions and they will be major regions for the future extending of irrigation area. The north-western part and some areas of the Yellow, Huai and Hai river basins have also certain potentials to tap.

According analysis and forecast, the irrigation area of the whole country will be increased by more than 0.1 billion mu and the total irrigation area will attain 0.9 billion mu by year 2030. The objective of 0.95 billion mu will be attempted, with the per-capita area of irrigation slightly lower than the present 0.63 mu. Beside large key projects, it will be necessary to construct small storage, lifting and diversion works. If 65% of the irrigation are is for grain crops, based on the estimated incremental yield of 400 kg/mu, the total output of grain will be increased by 26 billion kg.

(2) Rehabilitation and modernization of existing irrigation systems
At present, farmland with irrigation works yields on average grain of 500-600 kg per mu. This level of production may be deemed relatively high but is still below that of advanced countries: generally, our rice yield is 60-80 kg lower, wheat 100-200 kg lower, and maize 200-300 kg lower. Of 800 million mu of irrigated farmland, some 200 million mu under grain farmland gives poor yield because of water shortage, water loging, saline-alkali, etc. This cropland is called "middle-low yield cropland". Through improvement and management, each mu may give an additional yield of 150 kg, hence comes an additional gross production capacity of 30 billion kg. Moreover, another more than 300 million mu of grain farmland will be progressively modernized and provided with advanced agricultural techniques and this will also give an additional yield of 70 kg/mu to result in an additional gross output of 21 billion kg. The two possibilities all together will give an total additional production capacity of 51 billion kg.

(3) Insuf ficiently irrigated and rain-fed ag riculture More than 1 billion mu of dry land (without irrigation conditions) will be improved via insufficiently irrigated and rain-fed agricultural techniques to raise the production. If 70% of this land will be planted with grain crops, additional per-mu yield will be 50 kg, giving rise to a gross production capacity of 36.8 billion kg.

The above-mentioned three items all together can give an additional food production capacity of 113,8 billion kg (see Table 2):

Table 2 Analysis of potentials for increasing food production capacity by 2030

Genre of farmland		Food farm-land (mu)	Additional yield (kg/mu)	Potential (0.1 billion kg)
Existing 0.8 bil-lion of irrigated farmland	Middle-low yield cropland	2	150	300
	Other farmland	3	70	210
Newly added 100 million mu of irrigated farmland		0.65	400	260
1.05 billion mu of rain-fed farmland		7.35	50	368
Total				1138

Emphasis must be placed on three points: first, increasing the 21-st century's agricultural production and efficiency will depend mainly upon the progresses of agricultural science and technology. However, water is the basis for making the most of agricultural techniques; second, taking into account the necessity for augmenting the peasants' income, the proportion of economic crops in agricultural farmland with irrigation facilities has to be increased from 30% to 35% or even more; third, in the future the process of world economic and trading integration will be sped up. While ensuring the stable augmentation of food production, the development of agricultural products with high added values is imperative. In this article, only the potentials and capacity are analyzed.

3. Analysis for irrigation water use

The extension of irrigation area and improvement of existing irrigation systems require additional water supply. It is expected that, after 2010, agricultural production techniques and irrigation methods will achieve very marked successes and the specific water use of irrigation area will be reduced significantly.

(1) The existing irrigation farmland with an area of 0.8 billion mu needs 360 billion m^3 of water Some of this area is short of water supply with a deficit of more than 30 billion m^3 and in some places with well irrigation the underground water has been over-exploited. Simultaneously with water shortage, several problems exist in relation to extensive water use management with a coefficient of irrigation water efficiency of 0.4. The main approach to improving the water shortage of existing 0.8 billion mu irrigation area shall be water saving and tapping the potentialities. It is expected to have possibility to raise this

coefficient to 0.6 by 2030 to reduce water use of some 70 billion m^3. Of the saved water, more than 30 billion m^3 will be used for filling up water shortage for irrigation area to raise irrigation reliability, 15 billion m^3 for satisfying the water requirement for newly added irrigation systems and the remaining for compensating underground water over-exploitation and improving the ecosystems.

(2) Water use for the newly added irrigation area of 0.1 billion mu It is expected that by 2030 gross irrigation norms will be decreased to some 450 m3/mu and the newly added irrigation area of 0.1 billion mu will require approximately 45 billion m^3. According to planning, there will be at that time a new water supply of 30 billion m^3 to be used. Of it, 20 billion m^3 will be found in the Yangtze basin and areas south of it. Beside that, the water use of existing irrigation systems will be of 15 billion m^3 less because of application of water saving technologies. Newly developed water sources will be substantially found in the Yangtze basin and areas south of it with a low level of water resource exploitation as well as in the north-eastern part, including the water supply by the South-North Water Transfer from Yangtze to northern areas for the purposes of agricultural use.

(3) Environmental impact At present, the Yangtze basin and areas south of it have rate of water resource exploitation of 12%. An additional irrigation water supply of about 20 billion m^3 will raise this rate by 1%, which has no unfavorable impact on the environment. The north-eastern part of China has now a rate of 25.9%, increasing water supply for irrigation by several billion m^3, will also have no significant impact on the ecosystems. Moreover, spreading water saving techniques and gradually reducing underground over-exploitation and excessive water uses in some ecologically fragile regions will to a certain extent improve the situation of ecosystems.

4. Food safety analysis

By 2030 China's food production capacity will attain some 614 billion kg, accounting for 96% of the total demand of 640 billion kg and China will be practically self-supporting. The deficit of 26 billion kg will be filled up with import from international market. Taking into account that the gross food production level of the world in 2030 will be greatly raised compared with that of the present time, China's food import of 26 billion kg will not exert a significant influence on the situation of international

III. MAIN ISSUES

China's irrigation development in the 21-st century will be faced wiht the following issues:

1. The difficulties of irrigation area expansion will be increasingly large

After large-scale development during the last decades many of water and soil resources easy for exploitation have mostly been harnessed and the difficulties new irrigation area harnessing will be increasingly large. The constraining factors are: sparse rain, water shortage, difficult topography, disperse land, poor soil and lacking of good topographic and geologic conditions for reservoir construction.

2. Heavy tasks for water saving

To maintain the balance between water supply and demand, the country's average application efficiency of irrigation water use has to be raised from 40% to 60%, which is a difficult task. This means, most of canals must be lined, or converted from open channels to pipes. In-farmland irrigation will be equipped with advanced, highly efficient irrigation methods and techniques. Working from the present situation, we still have a long way to go.

3. Existing irrigation works with low criterion, without perfect accessories, out of date and repair

Most of existing irrigation works were built from fifties to seventies and many of them lack necessary accessories. After a long period of use, about one third of them have been aged and damaged. And, we are far behind of developed countries in irrigation method and technology. The proportion of mechanized and automated irrigation operations is now small and these operations are usually performed manually. Among the farmlands with irrigation works, approximately one third have a low yield.

4. The system of irrigation management is not successful lacking vigor and high level of management.

The irrigation works management lacks clearly defined duties. The water charges for irrigation are under-estimated, without necessary funding for repair and rehabilitation. Management organizations are over-staffed and low-qualified. Irrigation management still relies on experience and manual operations whereas new technologies such as computer, information, etc. have not yet been widely used.

IV. MEANS AND MEASURES

We have already overcome many difficulties and solved the problem of supporting a population of 1.2 billion. We are sure that China can solve the problem of feeding a population of 1.6 billion in the next century with correct policies, science, technology and Chinese people's diligence and intelligence. We will provide a stable basis for the sustainable development of economy and society in China. The means and measures are the following:

1. Put agriculture in the first place for the development of national economy, speed up agricultural capital construction with irrigation as the focal point, grasp firmly food production, develop a diversified economy in every possible way

China has a large population and the peasants have a large proportion in the whole population. China is a large country but has a low level of economic development. To ensure continuous and normal growth of economy, we must put agriculture in the first place for the whole national economy. In any cases, we need to grasp firmly food production to ensure food safety. In order to maintain the solidity of agricultural foundation and sustainment of economic development, the Chinese government has always taken irrigation as the lifeblood of agriculture, in a remitting manner organize the peasants to build water conservancy woks and develop irrigation. We did it like this in the past and will uphold such a policy in the future.

2. Emphasis is put on the following principles: developing irrigation according to local conditions, scientific planning; pay attention to both irrigation and drainage, combination of storage with diversion and lifting, simultaneous construction of small-, middle- and large-scale works and rational development of water resource.

(1) In hilly and mountainous areas, maintain water sources and conserve water and soil by transforming sloping farmland into terraced fields and combining engineering measures with biologic ones to raise per unit area yields; organize the peasants to construct more storage works and develop irrigation;

(2) In low-laying and logging plains, take drainage as the key measure, while paying attention to drought resistance and irrigation, construct the farmland capable of ensuring stable yields despite drought or excessive rain;

(3) In areas with insuf ficient water resource, sink wells to tap

underground water, develop well irrigation, complement surface water and underground water mutually; in some convenient places, construct rubber dams and retention sluices for artificial recharge of underground water;

(4) In the north-western part, in areas with water sources, divert river water for of gravity irrigation, or build pumping stations for lifting water to irrigate; in areas with meager water resource, construct artificial rain collecting spaces for using roof, road, natural sloping land, etc. to develop insufficient irrigation;

(5) In the north-eastern and northern parts where application of sufficient irrigation is not possible, spread injection irrigation to rate, the rate of seeding growth under drought; during the latter growing period, rely mainly upon natural rainfall;

(6) Implement inter-basin water transfer to solve the problem of insufficient water supply for irrigation in some areas.

3. Water saving, high efficiency water use, constructing water-saving-style agriculture

(1) Line eriously impervious earth canals properly. At present, one fifth of our canals in the country are lined, 70 million mu of agricultural farmland is already provided with water transferring pipes instead of open canals, with a total length of about 400 thousand km.

(2) Level land, improve the size of irrigation borders within the fields, change large borders into small and long ones into short, construct high level garden-style farmland; some advanced techniques such as sprinkler irrigation, drip irrigation, etc, if possible, may be recommended;

(3) Utilize poor quality sources such as return flow from irrigation, treated waste water, brackish water, etc.;

(4) Guide irrigation to use scientific irrigation systems, reduce the number of irrigation operations and irrigation norms, spread controlled-irrigation techniques;

(5) Develop ag ricultural water-saving measures, g row and spread drought resistant species, regulate cropping pattern, reduce planting area of water-intensive crops; raise the capacity of water detention and conservation in soil; cover ground surface with straw, plastic membrane, etc. to reduce moisture evaporation from soil; use chemical drought resistant preparations to raise the capacity of water conservation in soil and the drought resistant capacity of crops, etc.

4. Pay attention to reforming irrigation systems

Continuously build, perfect and reconstruct irrigation systems to raise their reliability for water supply and irrigation quality, tap the potentials

of agricultural production, which is cost-effective results and thus should be one of the main policies for future development of irrigation.

5. Advance the reform of water pricing

In 1985, the central government stipulated the principle of collecting water charges according to the cost. In the past ten years, the level of water charge has gradually risen and it now accounts for one second and two thirds of the cost. In the future, this reform will be sped up in order to realize self-supporting of irrigation works.

6. Reform the system of irrigation management and promote participation of peasants in management

For small irrigation works, whoever is benefited shall make investment. The peasant who builds irrigation works shall take part in management. For key projects in large-scale irrigation systems, the specialized authorities shall be responsible for the maintenance and management and the participation of peasants in their irrigation management is recommended.

7. The government supports the development of irrigation

Taking into account that food is a special product whereas irrigation works mainly serve food production and have a certain feature of public goal, our government has always supported irrigation construction in numerous ways such as financing the key projects of large scale, arranging some subsidiaries and bank loans for small works.

8. Insist on integration of economic, social and ecosystems benefits; realize sustainable utilization of water and soil resources, as well as sustainable development of agriculture; and avoid adverse effects on the ecosystems.

VI. CONCLUSIONS

China is a country with a large population and also a developing country. According to the natural and socio-economic conditions, China must pay attention to agriculture and irrigation development. The development of irrigation is a necessary condition for the augmentation of China's food production.

The irrigation development and food production in China face a severe situation and greatest challenges. We fully understand that we'll have big difficulties in solving this problem but we also notice the existing potentials of development. The above-mentioned analysis has shown that

we can achieve the goal of food self-supporting by simply having proper policies and measures, modern science and technology as well as bringing the diligence and intelligence of the Chinese people into full play. We must attain this aim. China is a large agricultural country. China's irrigation development and food production not only will exert no adverse effects on the world but also will make his due contribution to the cause of world food safety, peace and progress.